sick, varies from 0 to 1. [Hint: draw a coordinate plane with \( p \) on the x-axis and \( M \) on the y-axis.] Based on this graph, under what conditions is she least likely to buy the subsidized insurance?

**Essay questions**

15 Health insurance is normally seen as a good that is most valuable to sick people, since health expenditures are highest for the sick. Yet, in the basic insurance model discussed in this chapter, actuarially fair health insurance is worth nothing to people who are certain to become sick \((p = 1)\). Why does the standard model produce this result? How is this different from the way real-world insurance markets work?

16 In the basic model of insurance, income is the only input into a person’s utility. This is obviously not realistic. If we relax our assumption that utility is determined only by income levels, can any insurance contract provide full protection against the possibility of becoming severely ill? Give examples of risks associated with becoming sick that are not typically covered by formal health insurance. Can you think of ways that people informally insure against these “uninsurable” risks?

Students can find answers to the comprehension questions and lecturers can access an Instructor Manual with guideline answers to the analytical problems and essay questions at [www.palgrave.com/economics/bht](http://www.palgrave.com/economics/bht).

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**8 ADVERSE SELECTION: AKERLOF’S MARKET FOR LEMONS**

Consider a man who walks into a life insurance office, asking for a million dollar policy against dying tomorrow. He tells the insurance agent that he does not smoke or drink, and by all appearances seems to the agent like a perfectly healthy young man. The policy the man wants will only last a day – if he dies tomorrow, the insurance company will owe his heirs a million dollars. The insurance agent faces two questions. Should the company provide coverage to this man at all, and if so how much should the man be charged as a premium?

The savvy insurance agent realizes that there must be something wrong in this situation. The man insists that he is healthy and wants the policy “just in case,” but if that is true, then why does he want such a generous policy over, such a short period of time? He must be hiding something important, the insurance agent reasons, something that will put him at significant danger of dying tomorrow. Though the insurance agent can never directly observe the potential customer’s risk of dying, the very fact that the customer wants to buy this unusual policy provides evidence that the customer is likely to die tomorrow.

It will be difficult to find a good price for this contract, as well. Suppose the agent offers this insurance for an astronomical price. If the customer is still willing to take the contract at this high price, this is further evidence that the man is sure of his fate, and might cause the agent to retract her offer and demand an even higher price.

The main problem inhibiting trade in this story is that the insurance agent and the potential customer do not have equal access to a key piece of information – the customer’s health risks. The customer is in a much better position to observe this fact, and he has a strong incentive to represent himself as healthier than he actually is, since healthier customers will tend to be charged a lower premium for the policy. This asymmetry in the information between the buyer and the seller makes it difficult to write insurance contracts that benefit both the buyer and the seller. As we will see, insurance markets work best when buyers and sellers are identically knowledgeable about the probability of different outcomes but identically ignorant about which outcome will occur.

In Chapter 7, both the insured individual and the insurance company knew in advance the individual’s probability of sickness and could set premiums and payouts accordingly. Typically though, insurance firms and customers do not share identical knowledge. Firms, which view customers from a distance, might have trouble judging who is likely to stay healthy and who is likely to get sick. Meanwhile, customers familiar with their own medical history and unhealthy habits have intimate knowledge of their own risk.

There are thus two related concepts to analyze in the market for insurance: uncertainty and information. As we have seen in the last chapter, uncertainty by itself does not impede the market from functioning well. A theme of this chapter is that asymmetric information about that uncertainty can pose a more existential threat to the market. The major problem is that the party with more information has incentive to misrepresent himself to
obtain better terms in the transaction – in other words, to lie about his position. The party with less information anticipates this dishonesty and takes action to protect herself.

Definition 8.1

Information asymmetry: a situation in which agents in a potential economic transaction do not have the same information about the quality of the good being transacted.

The used-car market is the standard context to start exploring these themes. This market is sometimes known as the “market for lemons,” because defective used cars are known colloquially as lemons. Misrepresentation is common in this market, which is notorious for seedy salesmen and suspect merchandise. Even though used cars and insurance contracts are very different things, the lessons about asymmetric information that we learn here can be applied readily to insurance markets.

8.1 The intuition behind the market for lemons

Imagine a well-functioning used-car market. Sellers advertise prices for old cars they no longer want, while potential buyers scour websites and classified ads looking for good deals. If they find a potential match, the buyers visit the sellers and examine the vehicle for sale. They kick the tires, peer under the hood, or take the car for a test drive in hopes of assessing the vehicle’s condition.

Let us suppose that these simple diagnostic techniques are sufficient to uncover any problems. Buyers who open the hood of their potential new ride will notice if critical car parts are missing, or are held together with duct tape. Then the seller and buyer have identical information about the quality of each car, so the price of each car adjusts to reflect its specific quality. This market will function well.

Nobel prize-winning economist George Akerlof imagined what would happen if the used-car market described above suffered from information asymmetry (Akerlof 1970). Sellers know all about the problems that their cars have, but crucially buyers do not. Buyers can test-drive cars all they want, but they cannot make a confident quality assessment.

If any cars are to sell at all in this market, they must all sell at the same price. To show this, we argue that a market for used cars with two prices must converge to a single price. Suppose that there are two cars in this market, one for sale at a high price $P$ and one for sale at a low price $P' < P$. Since they cannot tell the difference between the two cars, buyers consider the two cars as identical and they would never pay the higher price. Hence, only the car at the lower price has any chance of selling. And as a result, the seller at $P'$ must lower his price to $P$ to have a chance of finding a buyer.

From the previous paragraph, we can conclude that any cars that do sell must sell at exactly the same price. The next step is to see if any cars sell at all at a single price $P$. We will show that, under certain conditions, for this $P$ no cars will sell. And since $P$ was selected arbitrarily, we can assert that there is no $P$ under these conditions such that cars will sell.

The lot of used cars do not all have the same quality. The well-maintained ones are worth much more than $P$, but the rickety ones are worth much less. If $P$ is the market price, not all cars reach the market. The sellers who own cars worth more than $P$ will not want to put their cars on sale at all. Thus, the high-quality cars are withdrawn from the market, leaving only the low-quality ones. This is an example of adverse selection, which causes the market to unravel.

Definition 8.2

Adverse selection: the oversupply of low-quality goods, products, or contracts that results when there is asymmetric information. For instance, if a supplier of a product has better information about product quality than a buyer, then the highest-quality products will not be offered.

Now we have price $P$, where the highest-quality cars have been withdrawn from the market by their sellers. Consider the remaining cars. There is a distribution of value amongst these cars, and the most valuable of them will be worth at most $P$. Thus, the average value of the remaining cars is less than $P$. Buyers thus know that they would be purchasing a car worth much less than $P$, so unless the market price declines, buyers will refuse to purchase any cars.

Suppose a new price establishes itself below $P$. The same exact argument outlined above applies again. Sellers withdraw the top-quality cars, and as a result, the average worth of the cars remaining on the market falls further. Realizing that the market price still exceeds average value, buyers respond by refusing to purchase. With each new price drop and subsequent round of adverse selection, the car quality in this market continues to degrade until only the lowest-quality goods are still on the market. Depending on the exact utility function of buyers and sellers, even those may not sell.

It should be clear, at least at an intuitive level, why the market for lemons can fail under asymmetric information. Sellers cannot guarantee to buyers the quality of the cars they are selling, and sellers of low-quality cars have incentive to masquerade as high-quality sellers. The market fails because of a lack of incentives for honesty; instead, having the information advantage gives the sellers incentive to misrepresent the quality of their cars.

8.2 A formal statement of the Akerlof model

The intuitive story of the market for lemons should be clear at this point, but there are many nuances and limitations to this argument that only become clear with a more formal treatment. For instance, does the market still fall apart if buyers value cars so much that they are willing to pay top dollar for even the lowest-quality cars? Careful study of this formal treatment will help build the reader's intuition about the effects of adverse selection.
In addition, it will enable the reader to apply the logic of the Akerlof model to related situations and ask questions about the effects of potential government policies. The extensions we address later in this chapter include: What if the government introduced a price ceiling in this market? What would be the effect of a law that forbade low-quality cars from being placed on the market? Under these conditions, can the market work? The formal apparatus we develop next will enable us to answer these questions.

Seller and buyer utility functions

In the model, both sellers and buyers seek to maximize their own utility. At the beginning of the model, before any trades have taken place, each buyer and seller owns a set of cars, which we label 1 through n. Each car has exactly one owner. Of course, no one lives on cars alone; both buyers and sellers also derive utility from other goods, which we will call M.

Let the utility that a seller derives from the set of cars he owns and the other goods he consumes be \( U_b \). Let the utility that a buyer derives from the set of cars she owns and the other goods she consumes be \( U_s \). To keep things simple, we assume that buyers and sellers have the following utility functions:

\[
\begin{align*}
U_b &= \sum_{i=1}^{n} X_i + M \\
U_s &= \sum_{i=1}^{n} \frac{3}{2} X_i + M
\end{align*}
\]  

(8.1)

where \( X_i \) is the quality of the \( i \)th car owned by a buyer or seller. We will assume throughout that the price of a unit of other goods M is fixed at $1. This presentation of the analysis of the market for lemons follows Akerlof’s presentation in his classic 1970 paper.

Notice that these functions differ in one important way: a buyer values a car of given quality at 50% more than a seller would value the exact same car. The difference makes sense because buyers naturally desire cars more than sellers do — that is why the buyers are buying and the sellers selling. Additionally, these utility specifications imply that buyers and sellers are risk-neutral with respect to uncertainty about car quality. Doubling car quality, for example, exactly doubles the contribution of car quality to utility. In later sections, we introduce different utility functions.

Distribution of car quality

Sellers own cars of varying quality. For now, we assume that car quality X is uniformly distributed on a scale between 0 and 100:

\[ X \sim \text{Uniform}(0, 100) \]

Because of the nature of the uniform distribution, cars owned by sellers are equally likely to have quality level 3.14, 70.99, 99.999, or anything in between 0 and 100. Additionally, there is a \((100 - q)%\) likelihood that the quality exceeds q for any q from 0 to 100. Figure 8.1 shows the distribution of car quality.

Information assumptions

In introductory economics, we tend to study markets where both buyers and sellers share the same information about the quality of goods they are trading. In that setting, students should recall, the market price clears the market by equating supply and demand. In a market for used cars of varying quality with perfect information, each car of a given quality level is its own market, with its own market-clearing price. Higher-quality cars sell at higher prices than lower-quality cars because buyers value them more.

In Akerlof’s model of the market for lemons, however, buyers and sellers do not share the same information. Sellers know the quality of their cars; over time, they have observed how well their cars have been maintained, whether they suffered in any accidents, how they perform in cold weather, and whether anyone has vomited all over the back seat. But buyers know none of this and consequently cannot assess the true quality of any particular car.

But buyers are not uninformed; they know the form of the utility functions of the sellers. They also know the distribution of cars available for sale — how many cars of each quality level there are. They understand how the sellers react to changes in the prevailing price in the market. For instance, they understand that sellers will withdraw the highest-quality cars if the price does not justify selling. Therefore, the buyers know the distribution of cars actually placed on the market by the sellers at any given price. In other words, they understand how adverse selection works.

Recall that in the standard market, each car of a different quality level essentially represented its own market. In Akerlof’s model, though, all the cars in this market are indistinguishable to buyers. It is one big market and all the cars must share the single price P. No buyer would pay more than P for any car because good cars and lemons appear identical and paying more does not lower the probability of buying a lemon. This is actually a general property of markets with asymmetric information: goods of varying quality that would otherwise be in separate “markets” are lumped together in a single market with a single price.

When do cars sell?

Under asymmetric information, our goal is to find out if the market functions as well as it does under symmetric information. That is: do all trades that would be Pareto-improving actually occur?
Definition 8.3

Pareto-improvement: a transaction or reallocation of resources that leaves at least one party better off and no party worse off.

Our strategy is to propose a candidate price $P$ and ask which cars remain on the market at that price. Then we will see if buyers are willing to buy any of the remaining cars. We try every candidate price and see at which prices Pareto-improving, mutually beneficial trades actually occur. We will do this by evaluating the change in utility due to a transaction for both buyers and sellers.

Which cars will sellers offer?

In order for a seller to be willing to sell a car at price $P$, the utility from selling the car must exceed the value of the car to the seller. Before any cars are sold, the seller’s utility was

$$U_s(\text{before}) = \sum_{i=1}^{k} X_i + M$$

Suppose that a seller sells car 1 with quality level $X_1$. In this transaction, the seller loses $X_1$ units of utility but gains $P$ dollars with which he buys $P$ units of $M$, and hence $P$ units of utility. So his utility after selling is

$$U_s(\text{after}) = \sum_{i=1}^{k} X_i - X_1 + M + P$$

The change in seller’s utility $\Delta U_s$ from selling car 1 is

$$\Delta U_s = U_s(\text{after}) - U_s(\text{before})$$

$$= P - X_1 \quad (8.2)$$

Sellers put cars on the market if their utility increases from doing so. As we can see from equation (8.2), sellers gain utility from selling if and only if $\Delta U_s \geq 0$, which implies and is implied by $X_1 \leq P$. This means the car is offered on the market only if the quality level is less than or equal to the single price. In other words, this price serves as an upper bound on the quality of cars offered in the market.

For what follows, we need a bit of notation to define the set of cars put on the market at any $P$. Let $\Omega(P)$ be the set of all cars still on offer in the market at price $P$, which coincides with the set of cars with quality less than or equal to $P$:

$$\Omega(P) = \{i | X_i \leq P\} \quad (8.3)$$

Figure 8.2 illustrates the situation with price $P$. In the figure, the shaded area to the right of the vertical price line represents the cars withdrawn from the market because their value is so high that sellers would lose utility from selling them at $SP$. The unshaded area to the left of the vertical price line is the set of cars that are left on the market, or $\Omega(P)$, as defined in Equation (8.3). These cars all have quality less than $P$.

When will buyers buy?

We have established which cars are offered by sellers when the market price is $P$. To determine if transactions take place, we must also analyze the behavior of buyers.

At a given price $P$, a buyer is only willing to buy car $i$ if her utility increases from doing so. From the buyer’s point of view, the quality of the car she gets is uncertain. But it is drawn from a distribution that she does know, the distribution of $\Omega(P)$; that is, the set of cars remaining on the market after sellers have withdrawn the cars whose quality exceeds the selling price. So buyers have to make the decision to buy based on their expected utility from buying a car drawn from this set. They hope to get the best car available but may instead end up buying the worst.

If a buyer purchases a car, it will be her $(n+1)$th car, so we will label it car $n + 1$ with quality level $X_{n+1}$. In this potential transaction, she will lose $SP$ with certainty and hence $P$ units of other goods $M$ (since each unit of other goods costs $1$). In exchange, she receives a car of unknown quality.

To decide whether this is a good trade ex ante, the buyer evaluates all the possible levels of $X_{n+1}$ and thinks about the resulting utility from the best car, the worst car, and everything in between for all the cars in $\Omega(P)$. She knows to ignore the cars in the shaded area in Figure 8.2 because there is no chance the car she purchases will be from that region.

Before the potential transaction, the buyer’s utility (equation (8.1)) is

$$U_b(\text{before}) = \sum_{j=1}^{n} \frac{3}{2} X_j + M$$

Given our specification of the buyer’s utility, the buyer would gain $\frac{3}{2} X_{n+1}$ utility units from purchasing this car, and would lose $P$ units of $M$. After buying car $n + 1$, her utility would be

$$U_b(\text{after}) = \sum_{j=1}^{n} \frac{3}{2} X_j + \frac{3}{2} X_{n+1} + M - P$$

But the buyer does not know the actual value of $X_{n+1}$, and hence cannot compute $U_b(\text{after})$. However, since she knows $\Omega(P)$ and the distribution of cars on the market given $\Omega(P)$, she can calculate her expected utility from buying the car. The change in her expected utility is
\[ \Delta E[U_a] = E\left[U_a(\text{after}) - U_a(\text{before})\right] \\
= E\left[\left(\sum_{j=1}^{n} \frac{3}{2} x_j + \frac{3}{2} X_{n+1} + M - P\right) - \left(\sum_{j=1}^{n} \frac{3}{2} x_j + M\right)\right] \\
= \frac{3}{2} E[X_{n+1}] - P \tag{8.4} \]

Buyers only purchase cars if their utility levels increase from doing so. As we can see from equation (8.4), the buyers’ expected gain in utility from buying is positive if and only if
\[ \frac{3}{2} E[X] - P \geq 0 \]
\[ \frac{3}{2} E[X] \geq P \tag{8.5} \]

Another way to interpret this condition is that the expected marginal benefit of the purchase (the additional expected utility from car \( n + 1 \) with quality \( X_{n+1} \)) must outweigh the marginal cost of buying it, \( P \). Keep in mind that this expectation is computed with respect to the cars that are actually offered on the market, \( \Omega(P) \), given that the sellers withhold the best cars.

**The market unravels**

Now that we have the conditions for the sellers selling and the buyers buying, we are ready to assess this market’s ability to match these buyers and sellers at prices that induce them to trade. In this section, we consider a numerical example to make clear exactly how the market unravels.

Arbitrarily, we first assume a candidate price of \( P = 50 \). At this price, equation (8.2) implies that only cars with quality \( X \leq 50 \) reach the market. This is the effect of adverse selection.

Figure 8.3 illustrates the situation in this market. This figure is just like Figure 8.2 except that we have chosen a specific value of \( P \). Since the distribution of car quality is uniform to begin with, the distribution of car quality conditional on the set of cars that sellers actually sell, \( \Omega(50) \), will also be uniform. This is a property of uniform random variables. So the cars remaining on the market are uniformly distributed in quality from 0 to 50.

![Figure 8.3. Adverse selection in the used-car market with \( P = 50 \).](image)

At this point, since we know what cars are offered on the market, we are ready to determine whether any buyers will purchase them. To do so, we must evaluate equation (8.5) at \( P = 50 \). This equation calls for us to calculate the expected value of the random variable \( X_{n+1} \), which has a uniform distribution. Equation (8.6) contains this formula.

For a uniform random variable \( X \) which varies from \( a \) to \( b \), the formula for the expectation of \( X \) is
\[ E[X] = \frac{b + a}{2} \tag{8.6} \]

Applying this formula, taking \( a \) as the worst possible car quality and \( b \) as the best possible car quality, we find that the average quality of cars remaining on the market when \( P = 50 \) is 25:
\[ E[X_{n+1}] = \frac{50 + 0}{2} = 25 \]

How do buyers evaluate this distribution of cars that are on the market? We can calculate their expected change in utility from buying car \( n + 1 \) by applying the last line of equation (8.4):
\[ E[\Delta U_a] = \frac{3}{2} E[X_{n+1}] - P \]
\[ = \frac{3}{2} \cdot 25 - 50 \]
\[ = \frac{75}{2} - 50 \]
\[ = -12.5 \tag{8.7} \]

The buyers know that the average quality of cars still on offer in this market is 25. At this average quality level, it does not make sense for them to buy because \( P \) is 50. This means that a buyer is being asked to yield 50 units of utility for a car they expect to value at 37.5 utility units.

This is not a good trade for the buyers; their expected change in utility is negative.

**Why not just find a better price?**

No car sells if \( P = 50 \), but are there other prices that could induce trades between buyers and sellers? Unfortunately, the answer is no in this example; it turns out that if we pick any value for \( P \), the market runs into the same dead end.

First assume any value of \( P \geq 100 \). All cars will be offered, but any such price is too high to satisfy any buyers, because the expected car quality \( E[X_{n+1}] \) is 50. So the expected utility from buying a car is 75, lower than the costs of purchasing it.

Therefore, the only hope is \( P < 100 \). But in that case the average quality of cars on the market is \( \frac{75}{2} \) by the formula for the mean of a random uniform variable from equation (8.6):\[ E[X_{n+1}] = \frac{P + 0}{2} = \frac{P}{2} \]
The change in a buyer’s utility, should she buy a car at price \( P \), is given by equation (8.4),
\[
E(\Delta U) = \frac{3}{2} \times \frac{P}{2} - P = -\frac{1}{4} P
\]
So for any price less than 100, buyers will face the following choice. They can give up \( P \)
in exchange for a car that can be expected to give them only \( \frac{3}{2} P \) worth of utility. No matter the
price \( P \), this market unravels.

### 8.3 The adverse selection death spiral

Now we switch our focus to a health insurance market that actually looks quite similar to
the used-car market we just studied. First, we must make a few assumptions about the way this market functions to bring it in line with the very simplified world of the Akerlof model.

**Assumptions**
- Each customer \( i \) has an expected amount of health care costs over the course of the
  year \( X_i \).
- An insurance company offers a single policy with an annual premium \( P \). This full-
  insurance policy covers all health care costs incurred during the year.
- Customers are risk-neutral. Customer \( i \) will purchase insurance if and only if \( P \) is
  less than his expected health care costs \( X_i \).
- The insurers are not allowed to discriminate between healthy and sick, and must
  contract with any customer willing to pay the premium. They have no way to exclude
  more sickly customers from purchasing insurance.
- Expected customer health care costs \( X_i \) are distributed independently and uniformly
  in the population:
  \( X_i \sim \text{Uniform}([0, 20000]) \)

Take a second to compare this market with Akerlof’s market for used cars. You will see
that an extended analogy can be drawn. The “cars” here are the customers’ bodies, and the
“sellers” are the customers trying to convince the “buyers” (insurance companies) that the
“cars” are healthy and unlikely to break down. Just as a high-quality car is worth paying a
high price, a high-quality body should only be charged a low premium. And just as high-
quality cars leave the market when a universal price is set, high-quality bodies will leave
the market when a universal premium is set.

Suppose that the insurance company offers a contract with a premium \( P = 10,000 \)
in 2013. Half of the customers do not purchase insurance because their expected health
costs are less than the premium. Just as it was not worthwhile for sellers with high-quality
cars to enter the market in the Akerlof universe, it is not worthwhile for relatively healthy
people to buy health insurance in this market. The sickly customers, on the other hand—the
ones with expected health care costs exceeding \( 10,000 \) — sign up as quickly as possible
(see Figure 8.4). For these high-risk customers, this insurance contract is a great deal.

What happens to the insurance company’s books? Adverse selection ensures that the
insurer will lose money. The company collects \( 10,000 \) from each customer, but pays an
average of \( 15,000 \) for each customer’s health care. This means the insurance company
suffers an expected loss of \( 5,000 \) per customer.

![Figure 8.4. Adverse selection in the health insurance market.](image1)

After a round of mid-level executive downsizing at the insurance firm, consultants rec-
ommend raising premiums to \( P = 15,000 \) for 2014. If each customer costs the insurer
\( 15,000 \), the new premium should balance the company’s cash flow. Right?

Unfortunately, the consultants are wrong; they neglect the fact that adverse selection
will continue. Of the remaining enrollees, the healthier among them exit the plan, while
the sicker, more expensive, customers sign on for another year of coverage. This time, the
selection is even more adverse than before — only the sickest of the sick enroll. Now prices
have risen, fewer people are choosing to buy insurance, and the insurance company is still
unprofitable (see Figure 8.5).

![Figure 8.5. A second round of adverse selection.](image2)

Now the company collects \( 15,000 \) from each customer. And while some customers
cost slightly less or more than expected, collectively they average \( 17,500 \) in insurance
claims. This means the insurance company still loses \( 2,500 \) per customer.

With each successive correction by the insurance company, the premium increases,
subscription drops, and the remaining pool of customers gets smaller and sicker. This
cyclical phenomenon is called an **adverse selection death spiral**. It concludes with an
Akerlofian market collapse — as the insurance company eventually learns, it cannot make
a profit with any premium in this market. In Chapter 10, we will see evidence of real-life
adverse selection death spirals that happened just about like this.
8.4 When can the market for lemons work?

The conclusion that the market for lemons fails under asymmetric information is striking. If it were generally true that markets fail under asymmetric information, that would have important implications about the ability of markets to facilitate Pareto-improving trades. However, the model as we presented it depends on strong assumptions about the utility of the buyers, the utility of the sellers, the distribution of car quality, and the institutional setting, including the legal rules under which the market functions. If some of these assumptions are relaxed, the market for lemons may function, though not as well as in perfect competition when buyers and sellers have the same information about the cars. The goal of this section is to explore how robust the Akerlof model is to changes in these assumptions, and by extension to explore whether health insurance markets can be saved from the adverse selection death spiral.

What if buyers value cars very highly?

In the utility functions for buyers and sellers that we presented in equation (8.1), buyers valued a car of given quality 50% more than sellers. This is clearly an arbitrary assumption; for instance, there may be buyers who value cars at considerably higher margins. Suppose sellers and buyers have the following utility functions instead of the ones we presented in equation (8.1):

\[ U_s = \sum_{j=1}^{n} x_j + M \]

\[ U_b = \sum_{j=1}^{n} \frac{5}{2} x_j + M \]

(8.8)

The only difference between the old utility functions and the new ones is that buyers now value cars 150% more than sellers.

We start again, as usual, with a candidate price \( P \). Because the sellers' utility functions have not changed, their behavior is the same as before. The set of cars they place on the market will still be \( \Omega(P) \), and is still characterized by \( x_j < P \) (see equations (8.2) and (8.3)). In the numerical example above, where \( P = 50 \), the set of the cars offered on the market would still range in quality from 0 to 50, where the average quality of cars is still 25.

We turn next to buyers. Their behavior does change, since they now have a different utility function. They value cars on the market more, even though the distribution of car quality and average car quality have not changed. We must reexamine equation (8.4), reproduced here:

\[ \Delta E[U_b] = E[U_b(\text{after}) - U_b(\text{before})] \]

After plugging in the buyers' new utility function, we obtain

\[ \Delta E[U_b] = E\left[ U_b(\text{after}) - U_b(\text{before}) \right] \]

\[ = E\left[ \left( \sum_{j=1}^{n} \frac{5}{2} x_j + \frac{5}{2} x_{n+1} + M - P \right) - \left( \sum_{j=1}^{n} \frac{5}{2} x_j + M \right) \right] \]

\[ = \frac{5}{2} E[x_{n+1}] - P \]

which implies that buyers will purchase cars when

\[ \frac{5}{2} E[x_{n+1}] - P \geq 0 \]

\[ \frac{5}{2} E[x_{n+1}] \geq P \]

(8.10)

Will this condition be satisfied for our candidate price \( P \)? Recall that since we started with a uniform distribution of car quality, even after the sellers withhold the top-quality cars, the distribution of cars in \( \Omega(P) \) will still be uniform. We can calculate the expected value of car quality in \( \Omega(P) \) using equation (8.6):

\[ E[x_{n+1}] = \frac{P + 0}{2} = \frac{P}{2} \]

Given this average car quality, the change in utility from purchasing a car is

\[ \Delta U_b = \frac{5}{2} E[x_{n+1}] - P \]

\[ = \frac{5}{2} P - P \]

\[ = \frac{1}{4} P > 0 \]

(8.11)

These buyers gain utility from buying a used car on this market, almost no matter the price, even though they are fully aware that sellers withhold the top-quality cars. Actually, there is a price above which buyers no longer gain utility from buying a car. What is it and how does that change with the maximum quality of cars? With the buyers' utility function? Exercise 9 addresses these questions.

What if the government sets a price ceiling?

Governments often intervene in insurance markets by regulating the prices at which insurers can sell and by requiring certain kinds of risk-pooling. We say more about this in future chapters, but in this context, we can imagine a similar government intervention. Suppose a consumer-protection agency decides to set a price ceiling in the market for lemons in an attempt to protect buyers from being gouged by unscrupulous sellers. What effect does this price ceiling have on the market?

Surprisingly, the answer is almost none. To see this, consider again the case where buyers' utility is given by

\[ U_b = \sum_{j=1}^{n} \frac{3}{2} x_j + M \]

where they value any given car 50% more than sellers. In this case, the price ceiling does not change the logic of adverse selection at all. Sellers cannot charge more than the ceiling.
price, so suppose that sellers charge some price less than the ceiling. They will withhold the top-quality cars just as before—in fact, the price ceiling ensures that the best cars (those more valuable than the price ceiling) never reach the market under any circumstances. Buyers know this and, as before, value the typical car on the market less than the price, and the market collapses again.

Suppose instead that buyers value any given car 150% more than sellers, as in the previous example. In that example, buyers were always willing to purchase cars, almost regardless of the price. The price ceiling does not change that logic at all. The only thing it affects is \( \Omega(P) \) — the set of cars that sellers bring to the market.

In neither case does the price ceiling benefit buyers, and in some cases, may actually harm them. In the second example, where buyers value cars very highly, the price ceiling forces sellers to leave the highest-quality cars off the market. Those cars may have found buyers who would have benefited from a sale, even at a high price. Meanwhile, the other buyers in this example are unaffected by the price ceiling. This is a good example of an economic inefficiency induced by a well-meaning reform.

What if there is a minimum guaranteed car quality?

In many industries where the form of adverse selection we have been talking about exists, private groups have formed to address the market failure caused by information asymmetry. For instance, there are companies that will, for a fee, provide potential buyers with the complete repair history of any used car in the US. Additionally, government agencies sometimes fill the market’s information gap by requiring sellers to disclose problems to buyers or by enforcing a minimum standard of quality. The Food and Drug Administration, for instance, requires that new drugs meet a minimum quality standard before allowing pharmaceutical companies to place them on the market. The Akerlof model has implications for the efficacy of such interventions.

Suppose the state government passes a law banning the sales of cars with quality \( X_i \) \( < \) 10. Our goal is to see whether there are any prices at which transactions do occur. Suppose we have a candidate price \( P \). Given the sellers’ utility function in equation (8.1), sellers will place all cars \( i \) of quality between $10 and \( P \) on the market.

Figure 8.6 illustrates this new situation. The shaded areas represent cars that are not placed on the market, while the unshaded area represents cars that are offered for sale. Cars with quality less than 10 do not reach the market due to the new law. And as usual, sellers with cars of quality greater than \( P \) withhold their cars from the market. This means \( \Omega(P) \) has both a lower and an upper bound:

\[
\Omega(P) = \{ i | 10 \leq X_i \leq P \}
\]

(8.12)

It should be clear that \( P \) must be greater or equal to $10, otherwise \( \Omega(P) \) is the empty set and no cars would be offered on the market.

We find the new average quality of cars on the market by applying the formula for the mean of a uniform distribution (equation (8.6)):

\[
E[X_i] = \frac{P + 10}{2}
\]

(8.13)

implying that buyers will purchase cars so long as

\[
\Delta U_B = \frac{15}{2} - \frac{1}{4}P \geq 0
\]

(8.14)

For prices between $10 and $30, sellers place on the market cars of quality between 10 and \( P \). Buyers buy those cars because their utility increases from doing so. Therefore, this minimum-quality floor guarantees a range of prices where the market can function, even though it does not completely solve the market failure associated with adverse selection.

8.5 Conclusion

We have seen that asymmetric information can upend the used-car market, but it is important to note that all this talk about used cars is highly pertinent to insurance markets. Wherever asymmetric information is lurking, such as in transactions between a seemingly healthy person and an insurance agent, markets can unravel and fail. This is not to say that markets with asymmetric information will automatically fail. Remember, if buyers care enough about a product or if there are credible minimum-quality guarantees, the Akerlof market does not unravel.

It is important to remember that the Akerlof model is very simple, and abstracts away from risk aversion altogether to focus on uncertainty and asymmetric information. This is not an irrelevant omission. Introducing risk aversion may overturn the major results of
the Akerlof model. If it is the case that buyers are so risk-averse that they are desperate to avoid uncertainty, then maybe they will be willing to buy insurance even though they are getting a bad deal. The object of the next chapter is to introduce risk aversion into a model of asymmetric information and explore this possibility.

8.6 Exercises

Review the basic assumptions of the Akerlof model before answering these questions. Many exercises will refer to these basic assumptions.

Comprehension questions

Indicate whether the statement is true or false, and justify your answer. Be sure to state any additional assumptions you may need.

1. In the Akerlof model, suppose that the price of used cars is $P$ and the quality of used cars ($X$) held by sellers varies between 0 and 100. Suppose further that sellers’ utility is given by

$$U_s = M + a \sum_{i} X_i$$

where $M$ is the number of units of video games, which sell at $\$1$ per game, and $a$ is a utility function parameter that is strictly less than one ($a < 1$). Then sellers will offer cars with quality $X_i = P$ on the market.

2. In the model, buyers know the utility function of sellers, but do not know anything about the general quality of cars for sale.

3. If buyers care sufficiently more about cars than do sellers, then there are prices at which transactions can occur. In that scenario, there is no longer any adverse selection (although there still may be some information asymmetry).

4. The Akerlof model indicates that government intervention is the only way to solve the adverse selection problem.

5. If the quality of cars is normally distributed rather than uniformly distributed, the market will not unravel.

6. Ultimately, the market unravels because buyers are risk-averse. If buyers were risk-neutral, there would always be prices at which cars would sell.

Analytical problems

7. Review the basic assumptions of the Akerlof model. Assume that, in this market, the quality of cars $X_i$ is distributed as follows:

$$X_i \sim \text{Uniform}[q_l, q_h]$$

Note that in the discussion above, we analyzed the version of the Akerlof model where $q_l = 0$ and $q_h = 100$.

a. Let $q_l = 0$ and $q_h = 50$. Will any cars sell in this market? Explain your reasoning carefully.

b. Let $q_l = 0$ and $q_h = 200$. Will any cars sell in this market? Explain your reasoning carefully. Does raising the maximum quality of cars that sellers possess have any effect on predictions of the model? Explain why or why not.

c. Let $q_l = 50$ and $q_h = 100$. Will any cars sell in this market? Explain your reasoning carefully. Does raising the minimum quality of cars that sellers possess have any effect on predictions of the model? Explain why or why not.

8. In Section 8.4 we studied the case of a government-mandated ban on the sale of low-quality cars. Review the basic assumptions of the Akerlof model, assume that car quality $X_i$ is distributed uniformly from 0 to 100, and assume that the buyer and seller utility functions are as originally supposed in equation (8.1).

a. Let the government-mandated minimum quality be denoted as $B$. If $B = 50$, this means car $i$ can only be offered on the market if $X_i \geq 50$. What is the range of prices, if any, that would allow transactions if $B = 50$?

b. What if $B = 90$? $B = 5$?

c. Find the smallest $B$ for which you can still find prices that will allow transactions to occur. If there is no minimum, explain why not.

9. Consider again the example where buyers value cars much more than sellers. We assume again that

$$U_b = \sum_{j=1}^{n} X_j + M$$

$$U_s = \sum_{j=1}^{n} \frac{k}{2} X_j + M$$

Recall that, under these assumptions, any price $P$ such that $0 < P \leq 100$ induced at least some sales.

a. Will there be any transactions if $P = 150$? Why or why not?

d. What is the maximum price $P$ at which at least some transactions will occur?

e. Suppose instead that the buyer and seller utility functions are given by

$$U_b = \sum_{j=1}^{n} X_j + M$$

$$U_s = \sum_{j=1}^{n} \frac{k}{2} X_j + M$$

where $\frac{k}{2}$ reflects how much more buyers value cars than sellers. What is the maximum price at which at least some transactions will occur, in terms of $\frac{k}{2}$?

c. Assume further that the utility functions are still given by equation (8.16), but that car quality $X$ is distributed as follows:

$$X_i \sim \text{Uniform}[0, G]$$

where $G > 100$ is a distribution parameter. Now, what is the maximum price at which at least some transactions will occur, in terms of $G$ and $G$?

d. Interpret your findings about how the market’s functioning changes with $h$ and $G$ in non-mathematical terms.

10. Assume that instead of a uniform distribution, in this market, the quality of cars $X$ follows a triangle distribution from 0 to 100 as depicted in Figure 8.7. Given this new distribution, the formula for expected value of $X$ conditional on an upper bound $P$ is

$$E[X_i | G(P)] = \frac{2}{3} P$$

(8.17)